

Enhanced Mesh-Free Simulation of Regolith Flow, Phase I

Completed Technology Project (2011 - 2011)



Project Introduction

NASA needs simulation tools capable of predicting the behavior of regolith in proposed excavation, transport, and handling or sample acquisition systems. For engineering-scale problems FE analyses utilizing soil-mechanics-based constitutive models have long been utilized in civil engineering to evaluate stresses and deformations up to failure, even including some plastic flow. The extremely large strains, bulking and recompaction behavior in excavation, hopper flow and regolith processing, however, are generally beyond the capability of most FE codes. Mesh-free methods offer an attractive option – especially when coupled with critical-state soil-mechanics based constitutive models allowing unlimited shear deformation and flow. This Phase-1 project will enhance a new mesh-free SPH-based simulation model, initiated as part of an earlier SBIR project, to demonstrate its potential to meet NASA's need for a robust simulation tool for regolith manipulation and flow. Enhancements include providing smooth transitions as new free surfaces are created, parallelized algorithms so that high resolution can be maintained as the physical scale of the problems is increased to realistic engineering sizes, and inclusion of realistic cohesion in the critical-state soil-mechanics constitutive model. The large fraction of very fine particulates in lunar and Martian regoliths (e.g., particles < 20-microns) precludes particle-scale DEM models from ever being able to both maintain particle-scale fidelity and simulate engineering-scale problems. Utilization of larger-than-nature 'calculational particles' in DEM code leads to new challenges – calibration of those 'particles' so that the calculational material will reproduce the constitutive behavior of the original granular assembly. The mesh-free SPH model developed here has the potential to become a new robust simulation tool to address NASA's challenging regolith manipulation and flow problems.



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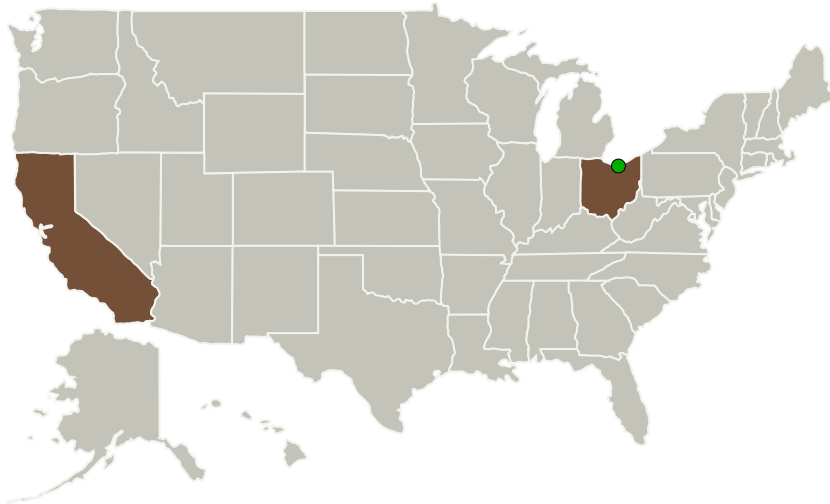
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Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Grainflow Dynamics, Inc.	Lead Organization	Industry	Livermore, California
● Glenn Research Center(GRC)	Supporting Organization	NASA Center	Cleveland, Ohio

Primary U.S. Work Locations

California	Ohio
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Project Transitions

February 2011: Project Start

September 2011: Closed out

Closeout Documentation:

- Final Summary Chart(<https://techport.nasa.gov/file/138135>)

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

Grainflow Dynamics, Inc.

Responsible Program:

Small Business Innovation Research/Small Business Tech Transfer

Project Management

Program Director:

Jason L Kessler

Program Manager:

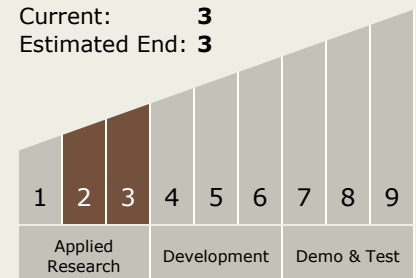
Carlos Torrez

Principal Investigator:

Scott G Johnson

Technology Maturity (TRL)

Start: **2**
Current: **3**
Estimated End: **3**



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Technology Areas

Primary:

- TX07 Exploration Destination Systems
 - └ TX07.1 In-Situ Resource Utilization
 - └ TX07.1.2 Resource Acquisition, Isolation, and Preparation

Target Destinations

The Sun, Earth, The Moon, Mars, Others Inside the Solar System, Outside the Solar System